CERTAIN FLOOD-FLOW PHENOMENA OF IOWA RIVERS

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1. *Elongated watersheds of Iowa streams.*—The characteristic long and narrow watersheds of Iowa rivers produce unique phenomena in flood hydrographs capable of analysis to a degree not possible for most streams with fan-shaped watersheds. The principal Iowa rivers originate in Iowa or Minnesota near the Minnesota border and flow diagonally across the State. The basins are usually narrow, with a length 8 to 30 times their average width.

2. *Iowa River flood.*—(*a*) A flood on the Iowa River in August, 1929, aroused particular interest on account of the peculiar hydrograph at Iowa City. The watershed had received no precipitation of significance during 17 days previous to this flood, and the entire flood was produced by an isolated intense rainfall lasting only a few hours and centrally located on the watershed. The study of such a flood avoids the complications generally resulting from storm rainfall unevenly scattered over a number of rainy days.

(*b*) The hydrograph of flow at Iowa City is shown in Figure 1. In shape it differs notably from the standard flood hydrograph in at least two particulars:

1. A double peak resulted from a single isolated peak of rainfall.

2. A sharp break occurred in the falling flood hydrograph, accompanied by an increase rather than a decrease in the rate of depletion of the flow.

(*c*) Apparently, both of the above phenomena may result from the physical characteristics of the river above Iowa City. Such phenomena no doubt occur in the floods of other streams, where the causes are less easily disclosed.

3. *Storm rainfall.*—The distribution of the storm rainfall of August 2, which caused the flood, is shown in Figure 2. Rainfall intensities were observed at Iowa City, 70 miles from the center of the storm. This was the only point within the storm area at which such observations were available. The graph of the Iowa City rainfall is reproduced in Figure 3, showing that the most intense precipitation was received between 4 and 5.45 a. m. on August 2. Near the center of the storm at Toledo, it was reported that most of the 8-inch rainfall was received between 11 p. m. on August 1 and 3 a. m. on August 2.

4. *Cause of double-flood peak.*—(*a*) The manner in which the precipitation was received offers no apparent solution for the double-flood peak. Likewise a long river with only minor tributaries entering along its stem would not normally be expected to cause the phenomenon shown in Figure 1.

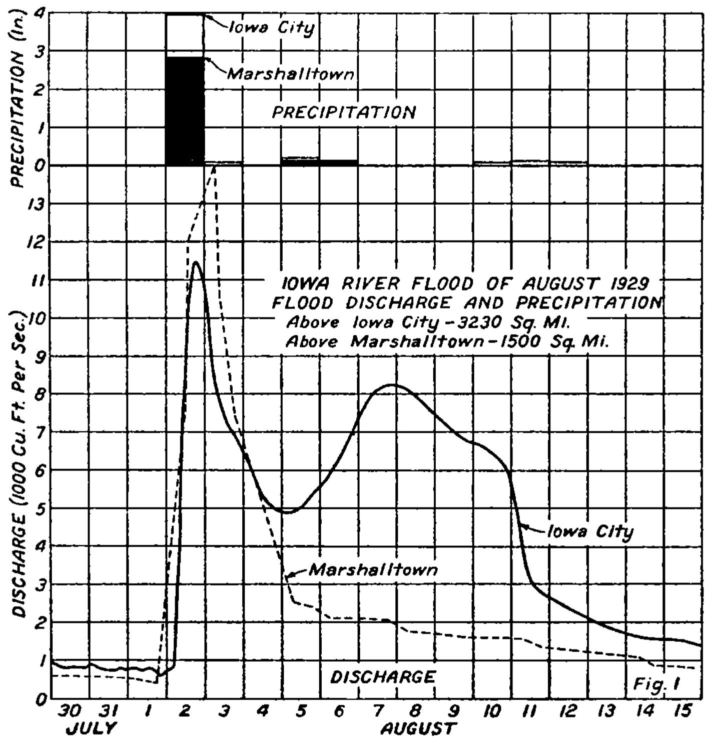
(*b*) The first peak undoubtedly resulted from rapid run-off from the hilly country extending upstream for 25 miles (to A, fig. 2) from the vicinity of Iowa City. In this region the river flows through a deep narrow valley with a flood plain extending only a few hundred feet outside of the main channel of the stream. Thus the first flood peak had all of the characteristics of rapid run-off combined with limited channel storage. The local freshet from this region actually receded before flood water was received from the heavier storm rainfall which fell on the portion of the watershed immediately upstream.

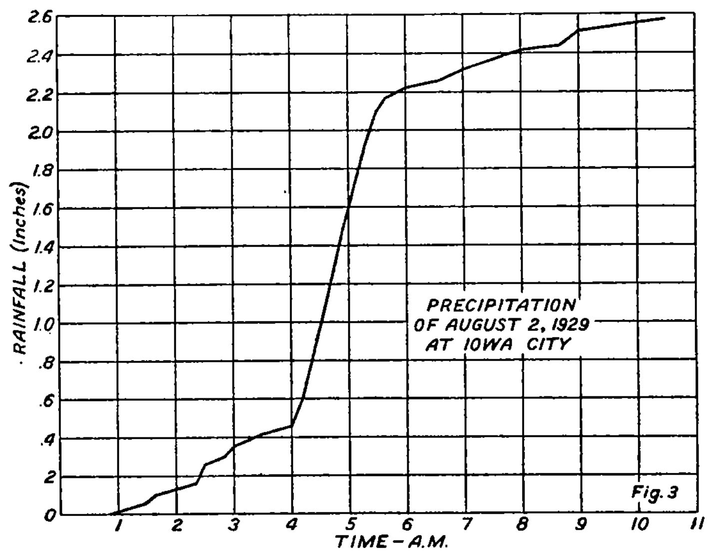
(*c*) The second peak following five days later had all the characteristics of flow retarded by storage. In this case, the storage utilized was in the valley of the stream itself. From (point A, fig. 2) to (point B, fig. 2) which is upstream about 100 miles, the valley of the Iowa River is 1 to 3 miles in width, with a present flood plain which is nearly a mile wide in places. When the river rises above an 8-foot stage, the flow spreads laterally over this flood plain, resulting in a reduction in the flood peak by the storage of a large volume of flood water in the valley. The rate of progress of the flood peak is likewise retarded. The simultaneous flood hydrograph of the Iowa River at the Marshalltown gage near the upper end of the storage area is also shown in Figure 1. At Marshalltown the river drains a watershed of only 1,500 square miles, yet it is noted that the peak flood discharge was higher than that at Iowa City where the drainage area is 3,230 square miles. Also, at this point only one normal flood peak resulted from the same storm. As the flood moved downstream from Marshalltown the peak discharge decreased even though it was joined by run-off from the smaller tributaries draining the land receiving the heaviest rainfall. This is typically a valley-storage phenomenon, which effectively retarded the run-off, spreading the second flood peak over a period of five days.

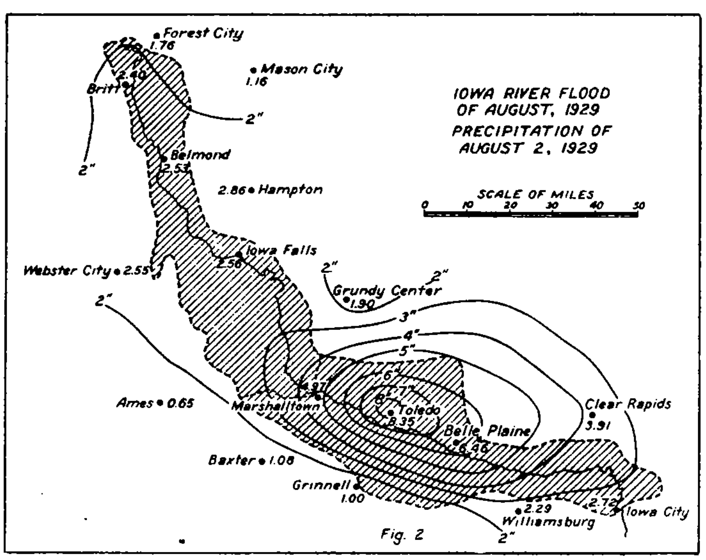
(*d*) The double flood peak has been quite commonly observed in other floods on the Iowa River whenever isolated storm rainfall falls on the watershed in the vicinity shown in Figure 2. It does not result when storms are confined to the upper portion of the watershed or from storms concentrated in the vicinity of Iowa City. The first peak is often higher than the second, depending upon the location and magnitude of the storm. This phenomenon has also been observed on other Iowa streams with similar physiographic conditions.

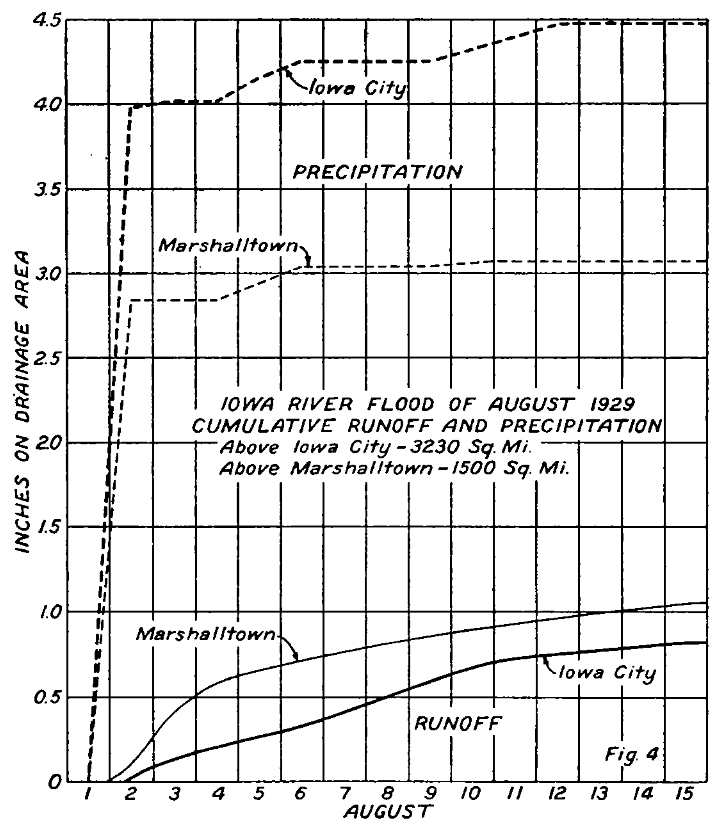
5. *Cause of break in rate of falling flood.*—(*a*) It will be noted that the break in the hydrograph of the falling flood occurred at a discharge of approximately 6,000 cubic feet per second. This phenomenon has been observed at Iowa City whenever flood peaks originate from isolated storm rainfall over the upper and middle portion of the watershed. The break in the flood graph generally occurs when the receding flood at Iowa City has fallen to a discharge between 6,000 and 8,000 cubic feet per second.

(*b*) The capacity of the Iowa River above Iowa City at bankfull stage is likewise equivalent to approximately 6,000 to 8,000 cubic feet per second. This fact at once suggests the cause for the break in the receding hydrograph. As long as a large amount of valley storage is available to replenish the flood flow, the rate of recession is slow, but when this reservoir of flood water has been exhausted, the flood flow is sustained only by the relatively small amount of storage within the river banks. Hence, as some have expressed it, "the bottom appears to drop out of the river," and the stream rapidly falls to a normal stage, where the discharge can be maintained by the inflow from the various tributaries. In floods, with rainfall scattered in time and distribution over the watershed, the above effect is often entirely obscured.


IOWA RIVER FLOOD OF AUGUST 1929
FLOOD DISCHARGE AND PRECIPITATION
Above Iowa City - 3230 Sq. Mi.
Above Marshalltown - 1500 Sq. Mi.
PRECIPITATION (In.)
PRECIPITATION
Iowa City
Marshalltown
DISCHARGE (1000 Cu. Ft. Per Sec.)
DISCHARGE
JULY
AUGUST
Fig. 1


PRECIPITATION
OF AUGUST 2, 1929
AT IOWA CITY
RAINFALL (Inches)
TIME - A.M.
Fig. 3


IOWA RIVER FLOOD
OF AUGUST, 1929
PRECIPITATION OF
AUGUST 2, 1929
SCALE OF MILES
Forest City 1.76
Mason City 1.16
Britt
Belmond 2.53
2.86 Hampton
Iowa Falls
Webster City 2.55
Grundy Center 1.90
Ames 0.65
Marshalltown
Toledo
Belle Plaine
Clear Rapids 3.91
Baxter 1.08
Grinnell 1.00
Williamsburg
Iowa City
Fig. 2


IOWA RIVER FLOOD OF AUGUST 1929
CUMULATIVE RUNOFF AND PRECIPITATION
Above Iowa City - 3230 Sq. Mi.
Above Marshalltown - 1500 Sq. Mi.
PRECIPITATION
Iowa City
Marshalltown
RUNOFF
INCHES ON DRAINAGE AREA
AUGUST
Fig. 4

6. *Percentage of run-off.*—(*a*) It is fortunate for agriculture in Iowa that the percentage of run-off from storm rainfall is small. In the August, 1929, flood, the percentage of the precipitation reaching the stream, amounted to only 18.3 per cent at Iowa City and 33.7 per cent at Marshalltown. Experiments indicate that very little, if any, of the midsummer precipitation percolates deep enough into the soil to replenish the ground water and replenish the supply available for subsequent run-off. Hence, the balance of the water was either evaporated immediately or stored in the upper layers of the soil for future evaporation and plant use. The graph showing the comparison of the cumulative run-off and precipitation is shown in Figure 4.

(*b*) In the following table, the percentage storm rainfall appearing as flood run-off is listed for other midsummer floods on Iowa streams. On the larger basins, the flood run-off rarely exceeds 30 per cent of the precipitation, although occasionally on some smaller watersheds almost 70 per cent of the storm rainfall has reached the streams.

TABLE 1.—*Percentage run-off of typical Iowa summer floods*

River	Gaging station	Drainage area, square miles	Date	Total precipitation, inches	Total run-off, inches	Per cent run-off of precipitation
Iowa	Iowa City	3,230	May-June, 1903	7.10	1.58	22.3
			May-June, 1918	6.99	2.36	33.8
			June-July, 1924	4.72	.84	17.8
			August, 1929	4.48	.82	18.3
Do	Marshalltown	1,500	do	3.07	1.05	34.2
Cedar	Cedar Rapids	6,570	May-June, 1903	5.75	1.09	19.0
Des Moines	Kalo	4,290	May-June, 1915	5.34	1.56	29.2
			July, 1920	4.53	1.36	3.00
Do	Keosauqua	14,090	May-June, 1903	8.53	2.59	30.4
			June, 1905	1.92	.49	25.6
			May-June, 1917	5.86	1.79	30.5
Raccoon	Van Meter	3,450	May-June, 1915	6.46	1.81	28.0
			May-June, 1917	5.95	1.88	31.6
			September, 1926	4.62	1.79	38.8
Skunk	Coppock	2,915	May-June, 1917	7.16	2.89	40.0
			May-June, 1918	7.16	2.00	28.0
			June-July, 1924	3.78	1.36	36.0
			September-October, 1926.	12.56	4.58	36.4
Do	Augusta	4,285	May-June, 1917	6.91	2.90	42.0
			May-June, 1918	6.10	1.64	26.9
			June-July, 1924	4.38	1.80	41.1
			September-October, 1926.	12.85	5.40	42.0
Do	Ames	315	June-July, 1924	2.54	1.40	55.1
Squaw Creek	do	205	do	2.29	1.54	67.3
			September-October, 1926.	12.85	3.35	26.1
Ralston Creek	Iowa City	3.0	June, 1926	2.65	.49	18.5
			September, 1926	1.98	.78	39.4
			do	1.84	.82	44.5
			May, 1927	1.04	.32	30.7
			do	1.23	.59	48.0
			do	.59	.41	69.5
			June, 1927	4.88	.05	62.4
			June, 1928	2.06	.52	25.0
			July, 1928	1.35	.19	13.8
			do	1.07	.45	41.7
			August, 1928	1.61	.61	37.9
			do	3.30	.90	27.0
			June, 1929	1.77	.34	25.4
			June-July, 1929	2.54	.71	27.9
			August, 1929	2.76	.76	27.5
			June, 1930	4.17	1.52	36.3
			do	1.11	.19	17.2
			September, 1930	5.07	1.28	25.2

THE TECHNICAL USE THAT ENGINEERS MAKE OF UNITED STATES WEATHER BUREAU OBSERVATIONS

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The work of the civil engineer embraces the planning, construction, and operation of both private and public enterprises and improvements. In connection with these activities he probably makes use of a greater variety of meteorological data than any other class of citizens, and in so doing affects the welfare of many people. It should therefore be of interest to meteorologists to know of some of the technical uses that engineers make of United States Weather Bureau observations. These are outlined in this paper together with suggestions as to ways in which the value of the observations could be increased.

PRECIPITATION

Precipitation is one of the most important classes of meteorological data which the engineer, and especially the hydraulic engineer, uses. It is fundamental to the planning of many projects and is very important in the design of hydraulic structures. It is necessary to know not alone the quantity of precipitation during long periods of time such as months, years, and groups of years, but also the rate or intensity for short periods of minutes and hours. The character of the precipitation, whether rain or snow, is also important.

Quantity.—Knowledge regarding the quantity of precipitation or depth in inches falling during periods of 24 hours or more, is of greatest importance in making water supply estimates for new hydraulic projects and for enlargement of existing systems. The proposed use of water may be for one of a great variety of purposes, such as domestic, industrial, municipal, irrigation, hydroelectric power, navigation, mining, or recreation. In every instance, however, it is necessary to know definitely whether sufficient water is available for the proposed use, both in the dryest season of the year and also during the dryest year which may be expected to occur. Streamflow measurements are of course depended upon to the extent available, but must usually be supplemented by studies of precipitation. The character of records required for this purpose range from long term average monthly and annual precipitation extending over periods of 50 or more years, to the actual precipitation which occurred on a specific day or during a certain storm. The data published in the monthly issues of Climatological Data are as much sought after in this connection as are the annual summaries or the occasional long-term summaries issued by the bureau.

In regions where there is a definite winter rainy season, such as on the Pacific coast of the United States, the compilation of precipitation data on the basis of the season instead of the calendar year is of great benefit to engineers, for it permits of immediate use of the data in water supply studies without the necessity of laborous preliminary computations. Precipitation records have been published